

5 Hamlin, Kenneth L
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ELK

Population Dynamics and Breeding Biology Gravelly - Snowcrest Mountains

PROGRESS REPORT ♦ 1991 ♦



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JOB PROGRESS REPORT

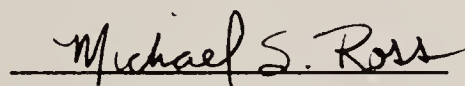
RESEARCH PROJECT

STATE:	<u>Montana</u>	
PROJECT NO:	<u>W-120-R-22</u>	TITLE: <u>Statewide Wildlife Research</u>
PROGRAM NO:	<u>I</u>	TITLE: <u>Big Game Research</u>
STUDY NO:	<u>BG - 3.1</u>	TITLE: <u>Elk Ecology Studies</u>
JOB NO:	<u>1</u>	TITLE: <u>Elk Population Dynamics and Breeding Biology</u>

Period Covered: July 1, 1990 - June 30, 1991

Prepared by: 
Kenneth L. Hamlin

Approved by: Terry N. Lonner
John P. Weigand
Donald A. Childress


Michael S. Ross

Date: December 31, 1991

Since this is a Progress Report only, results presented herein are not necessarily final and may be subject to change. For this reason, the information contained in this report may not be published or used for other purposes without permission of the Director.

OBJECTIVE

Assist with the compilation and evaluation of existing databases on several elk herds in Montana. Coordinate and recommend research and management studies and procedures which will provide for more effective management and a better understanding of elk population dynamics.

METHODS

Published and unpublished data continued to be compiled and evaluated. Meetings with MDFWP biologists, wildlife managers, and planners were continued to obtain their viewpoints and knowledge. This information will continue to be synthesized with the aid of the computer programs SAS, POSIM (Mooney and Lonner 1978), and TELDAY (Wildlife Div., MDFWP 1986) to better organize existing databases and evaluate elk management in Montana.

RESULTS AND DISCUSSION

Coordination with Montana Department of Fish, Wildlife and Parks' biologists and game managers was continued to address future management and research needs for elk. Response was given to a variety of requests for information and/or advice on elk management and research.

No further progress was made during the period in analysis of data on the Northern Yellowstone Elk Herd collected during the 1960s by Ken Greer.

A presentation, "Varying definitions of the legal bull - the effects on hunters, hunting, and elk populations", was prepared and given at the Elk Vulnerability Workshop in Bozeman. The presentation involved compilation and analysis of data from several Region 3 elk herds.

RECOMMENDATIONS

This aspect of the overall study should be continued in accordance with the objectives and methods stated in the 1988-1992 Application for Federal Aid for this research effort.

LITERATURE CITED

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JOB PROGRESS REPORT

RESEARCH PROJECT

STATE: Montana

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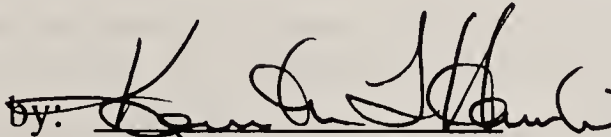
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TITLE: Elk Ecology Studies

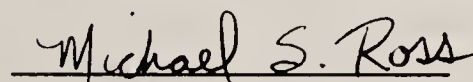
JOB NO: 2

TITLE: Elk Population Dynamics and
Breeding Biology

Period Covered: July 1, 1990 - June 30, 1991

Prepared by: 
Kenneth L. Hamlin

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INTRODUCTION

Elk (*Cervus elaphus nelsoni*) management in Montana has been primarily directed toward increasing elk numbers and maintaining a diversity of choice in elk hunting opportunity. In earlier years, diversity of choice was maintained by either-sex elk hunting. In 1963, 67% of Montana's hunted elk habitat was open to season-long either-sex hunting. More recently, season-long either-sex hunting has declined (to 1% of elk habitat by 1985) and diversity of choice has been maintained by a diversity of regulations among hunting units.

The any antlered bull regulation remained widespread, but an increasing number of hunting units were restricted to branch-antlered bull hunting. In 1981, only one hunting district (HD 324) was restricted to branch-antlered bull harvest. By 1985, 7 hunting districts had branch-antlered bull regulations and 2 were branch-antlered bull after an either-sex quota was reached. In 1989, 28 hunting districts and portions of 2 others had branch-antlered bull regulations.

In 1990, a brow-tined bull regulation was implemented in areas that previously had a branch-antlered bull regulation. Thirty hunting units had brow-tined bull regulations in 1990. This regulation is an attempt to reduce the degree of illegal mortality experienced under branch-antlered bull management (Hamlin and Ross 1990b).

Depending on the area, the branch-antlered bull regulation resulted either from concern over the long-term biological effects of yearling bulls siring most of the calves or from some hunters wanting to harvest a larger bull. Prior to implementation of this regulation, the MDFWP cautioned hunters that few bulls older than 2 years of age would be harvested.

Low observed calf:cow ratios in the Gravelly-Snowcrest Mountains during the winters of 1979-80 and 1980-81 (18-35 calves:100 cows versus 55-68:100 during 1970-75, Chrest and Herbert 1980 and 1981), coincided with low antlered bull:cow ratios. Available evidence suggested that low proportions of mature bulls in elk populations might negatively affect calf production and/or survival and population size (Hines and Lemos 1979, Prothero et al. 1979, and Smith 1980). Concern over the observed low calf:cow and bull:cow ratios resulted in changes in hunting regulations in HD 324 during 1981. The early archery season was eliminated, and the kill during the general elk season was limited to branch-antlered bulls. The branch-antlered bull regulation was also implemented in HDs 323, 326, and 330 during 1983 and HD 325 and the northern portion of HD 327 during 1987. The early archery season was restored in HD 324 during 1988.

This study was initiated in January 1984 to assess the role and importance of various hunting strategies on elk population characteristics and dynamics. Emphasis has been directed toward breeding biology, reproductive success, calf recruitment, seasonal

distribution, movements, and habitat use. Effect of various hunting strategies on hunter success, attitudes, and other factors was also evaluated.

OBJECTIVES

1. Determine the effects of alternate hunting regulations and harvest rates on elk population dynamics and habitat use.
2. Test the hypothesis that when mature bulls (2+ years) comprise less than 5% of an elk population during the breeding season, the net reproductive success will be less than when compared to when the population has greater than 5% mature bulls.
3. Assist biologists with evaluation of existing elk population data and utilize the results from this study to better understand elk population dynamics and manage harvests.

STUDY AREA

Because of low observed calf:cow and bull:cow ratios, the popularity of the area for hunting, and the changes in hunting regulations already in place, the Gravelly-Snowcrest Mountains in southwestern Montana were selected as the primary study area. In 1984 and 1985, work was concentrated on elk that winter on the Madison-Wall Creek Game Range (WCGR) south of Ennis. Elk that winter in the Cherry-Morgan area just north of Wall Creek were also captured and marked. The physiography and vegetation of this area have been described by Eustace (1967) and Gniadek (1987).

In 1986, work was expanded to include elk that wintered on the Blacktail Game Range (BTGR) southeast of Dillon. In spring 1989, study was expanded by marking elk that winter on the Robb-Ledford area, the Warm Springs area, and the Basin-Sage Creek area (Hamlin and Ross 1990a). The expanded study primarily involves current MDFWP hunting districts 323, 324, 325, 326, 327, and 330 (Fig. 1).

METHODS

Methods employed were similar to those reported previously (Lonner and Schladweiler 1987, Hamlin and Ross 1990b).

During February 1991, capture of 141 elk (79 at WCGR and 62 on the BTGR) was accomplished by helicopter drive-netting. As in 1990, we were successful in concentrating our capture effort on 9-month-old calves. Ninety-six of the 141 elk (68%) were calves.

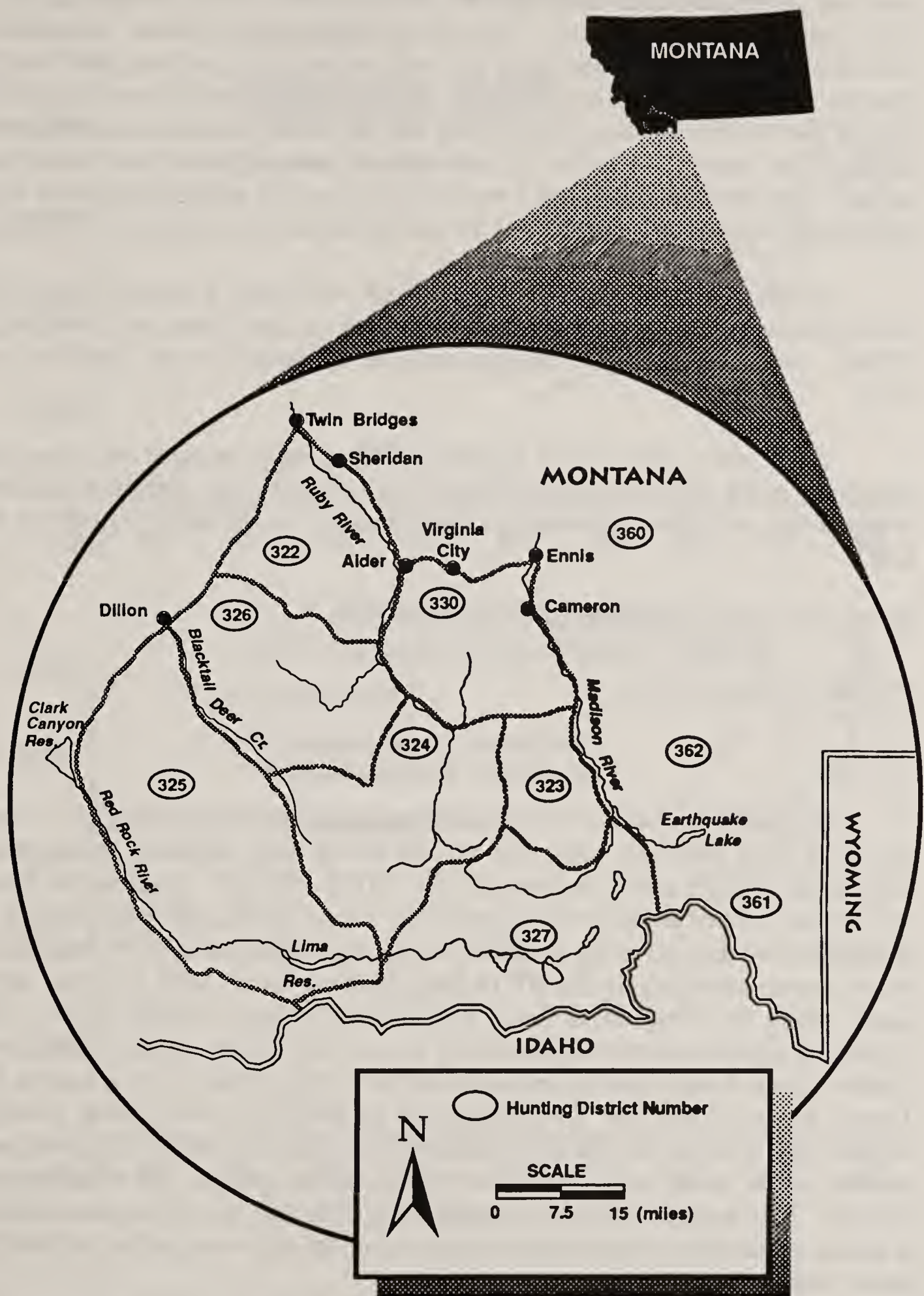


Figure 1. Location of hunting districts within the Gravelly-Snowcrest study area.

A total of 22 male and 30 female calves were captured on the WCGR and 14 male and 30 female calves on the BTGR. The male calves were all equipped with black PVC radio-transmitter collars. Fifty-five of the female calves were fitted with individually recognizable neckbands, four with eartags only, and one died from trapping injuries. Additionally, 25 adult females and two yearling males were captured on the WCGR and 16 adult females, one yearling and one 2-year-old male were captured on the BTGR. One yearling male and 16 adult females were equipped with radio-transmitter collars. Two yearling males, the 2 year-old male, and 23 adult females were fitted with individually recognizable neckbands. Two adult females were released with eartags only.

An incisor was collected from each elk older than 2 years during 1990-91 at check stations or from other mortalities. Age was assigned based on cementum analysis (Gilbert 1966) and compared to ages assigned by eruption-wear (Quimby and Gaab 1957).

As in prior years, blood samples collected from captured elk were tested for pregnancy using level of protein B (Sasser et al. 1986). Also, various blood chemistry, whole blood, and disease parameters were measured at the MSU Veterinary Research Lab.

RESULTS AND DISCUSSION

Population Characteristics

Numbers

Trends in numbers of elk observed during aerial surveys from 1947 to the present on the WCGR area and from 1948 on the BTGR area indicated an increase on the WCGR in 1990-91 and a decrease on the BTGR (Fig. 2). Information from radio-transmitter collared animals and observations during census flights indicated that lower proportions of animals were observed during census flights in 1990-91 than in other recent years, especially in the BTGR-Robb-Ledford area. With a milder winter than usual, many elk wintered in areas that are not normally winter range. Many elk (including radio-transmitter collared elk) that usually winter on the BTGR and Robb-Ledford Game Range spent the entire winter in the Upper Ruby area as well as in Clover Creek, Antone Creek, and the Middle Fork of Blacktail Creek. These non-traditional winter range areas were often more timbered than traditional winter range and we undercounted elk in those areas. Often, we found only the groups with transmitter-collared animals. This problem was less severe in the WCGR area because we were able to make a second census flight after a storm when most of the radio-transmitter collared elk were on or near traditional winter range.

Because of the foregoing considerations, more elk than normal were probably missed on all areas and trend counts (Fig. 2 and Table 1) indicating declines in elk

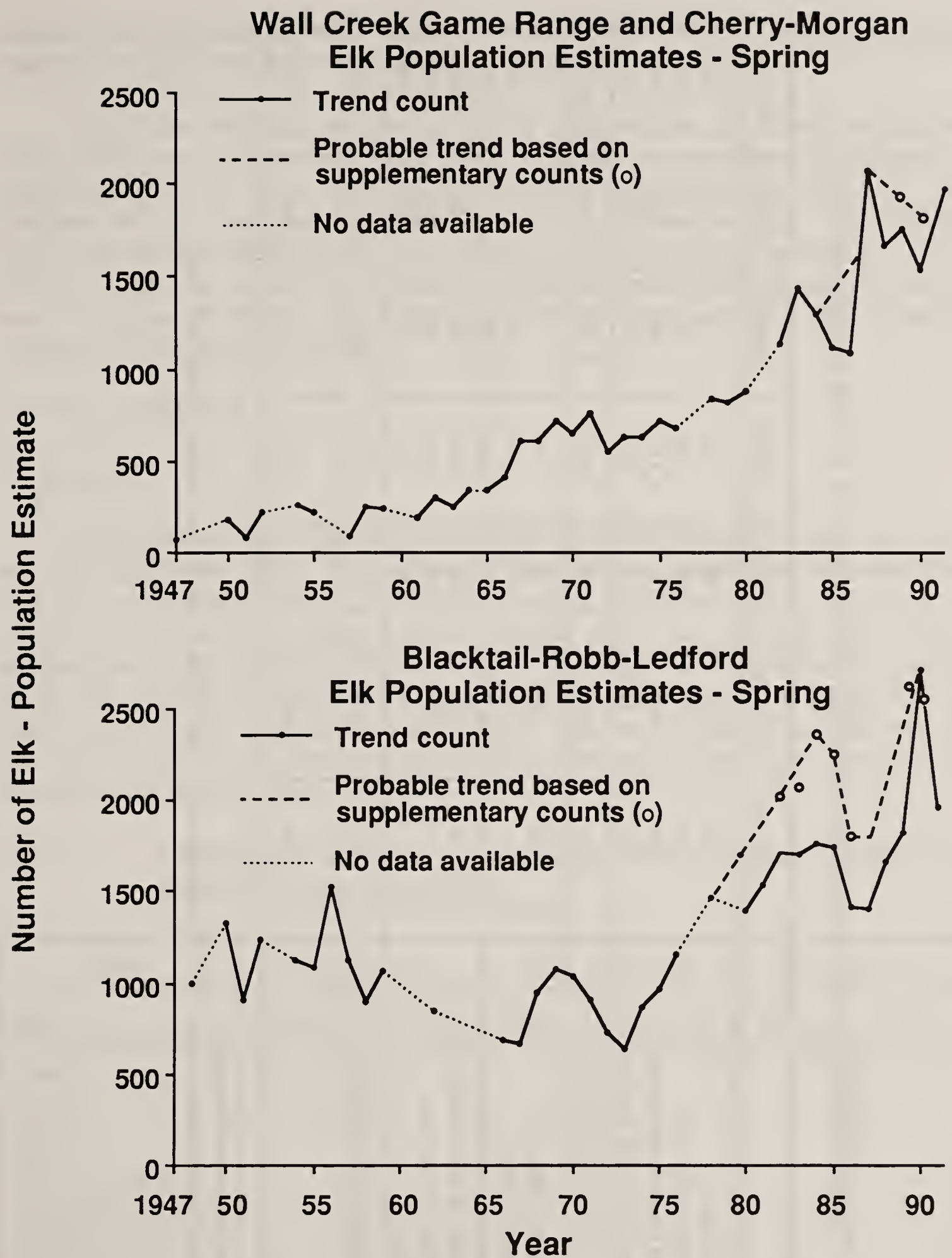


Figure 2. Trends in numbers of elk observed during winter aerial surveys of the Wall Creek Game Range-Cherry-Morgan area and the Blacktail-Robb-Ledford Game Range area, 1947-1991.

Table 1. General locations of elk observations and counts for the winters of 1984-85 through 1990-91.

	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91 ^b
Axlotl Lake Area	33	97	80	14	0	0	114
Cherry-Morgan Creeks Area	414	150	623	233	260	512	444
Madison-Wall Creek Game Range	664	805	1,233	1,182	1,401	880	1,249
Missouri Flats-West Fork Madison	---	35	134	132	91	157	162
Total for east side of Gravellys	1,111	1,087	2,070	1,661	1,752	1,549	1,969
North Centennial Valley	57	19	62	57	0	0	0
South Centennial Valley	---	---	---	---	---	310	93
Blacktail Game Range & Robb-Ledford Creeks	1,740	1,416	1,403	1,663	1,820	2,719	1,918
Greenhorn Mtns. & Lower Ruby River	---	323	432	463	317	458	418
Little Sage-Basin Creeks Area	---	199	365	322	490	537	442
Blacktail Ridge	---	---	189	273	425	493	284
Total for Blacktail-Centennial-Greenhorn Area	1,797	1,957	2,451	2,778	3,052	4,517	3,155
Grand Total	2,908	3,044	4,521	4,439	4,804	6,066	5,124

^a No flights were made over these areas

^b Because of wide dispersal during winter 1990-91, a greater than usual portion of the elk were missed during aerial counts.

numbers for many areas are not reliable. In addition to distributional information, other data also indicated substantial undercounts by census flights in 1991.

Population estimates made using hunting mortality rate of marked animals and other factors (see Hamlin and Ross 1990b) indicated a post-season population of approximately 9,819 elk in the Gravelly-Snowcrest complex during 1990-91. This compares to 7,360 estimated for 1989-90, 6,295 in 1988-89, and 5,060 in 1987-88. These data indicate an approximate 33% increase in elk numbers rather than the overall decline indicated by census flights (Table 1). Calf production was high and elk harvest was lower than previously, also indicating that the population should have increased compared to post-season 1989-90.

Sex and Age Structure

Classifications

Classification data, especially sex structure, were also affected by the mild winter and wide distribution by elk. Radio-telemetry information suggested that bulls may have been even more widely dispersed than cows. Sex and age classifications made from the ground (Table 2) indicated higher calf survival than previously, but slightly lower bull survival than during 1989-90. Higher numbers of 2+ year-old bulls were observed on the WCGR, however. Aerial classifications (Table 3) indicated lower percentages of bulls in 1991 than in 1990 (Hamlin and Ross 1990b) for all areas. Calf:100 cow and bull:100 cow ratios from 1968 through 1991 (Fig. 3) indicate little major change in any ratios over the last few years.

Table 2. Classification results from ground observations in the Gravelly-Snowcrest Mountains, winter-spring 1991.

Area	Wall Creek GR	Wall Creek GR	Blacktail GR
Date	February 8 & 9-91	March 14 & 15-91	March 6, 7, 8-91
Total	599	917	991
Cows	363	559	585
Calves	192	273	337
Bulls	44	85	69
Yearling 1X1	26	57	52
Yearling 1X2+	3	6	5
Raghorn Bulls	14	15	8
3+ Bulls	--	7	--
Unclassified Bulls	1	--	4
Calves:100 cows	52.9	48.8	57.6
Percentage bulls	7.3	9.3	7.0
Bulls:100 cows	12.1	15.2	11.8

Table 3. Classification results obtained during census flights, winter-spring 1991.

Location	Date	Total Number	Number Classified	Total Bulls	Bulls Classified	Ylg 1x1	Ylg 1x2+	Raghorn Bulls	3+ Bulls
Robb-Ledford R-L (in Upper Ruby) Total	2-27-91 2-27-91	251+ 211 462+	187 61 248	18+ 6+ 24+	18+ 6+ 24+	11+ 2+ 13+	1 1	3 1+ 4+	3 3
Blacktail Game Range Area									
Game Range Middle Fork Antone Peterson - Piute Total	2-27-91 2-27-91 2-27-91 2-27-91	588 344 167 244 1343	588- 29 167 244 1028	60 3 7 29 99	37 3 7 29 76	27 3 7 20 57	4 -- -- 4 8	6 -- -- 4 10	-- -- -- 1 1
Blacktail Ridge Basin - Sage Creek So. Centennial Greenhorns Warm Springs	2-27-91 2-27-91 2-27-91 2-27-91 2-27-91	284 442 93+ 214 204	236 442 -- 214 124	29 9 24 4	29 9 -- 24 4	26 8 -- 16 4	3 1 -- -- --	-- -- -- 7 --	-- -- -- 1 --
Blacktail GR (South & East to Piute Creek)	3-19-91	1456	1156	60	60	46	--	14	--
Wall Creek Game Range Area									
Axolotl Lakes Cherry-Morgan Wall Creek GR West Fork Madison Sheep Creek - Mile Creek Total	2-27-91 3-18-91 3-18-91 3-18-91 3-18-91	114 444 1249 1 161 1969	114 444 1249 1 161	11 27 129+ 1 5 173+	11 27 129 1 5 173	11 25 91+ -- 3 130+	-- -- -- -- -- --	-- 2 29+ 1 2 34+	-- -- 9+ -- -- 9+

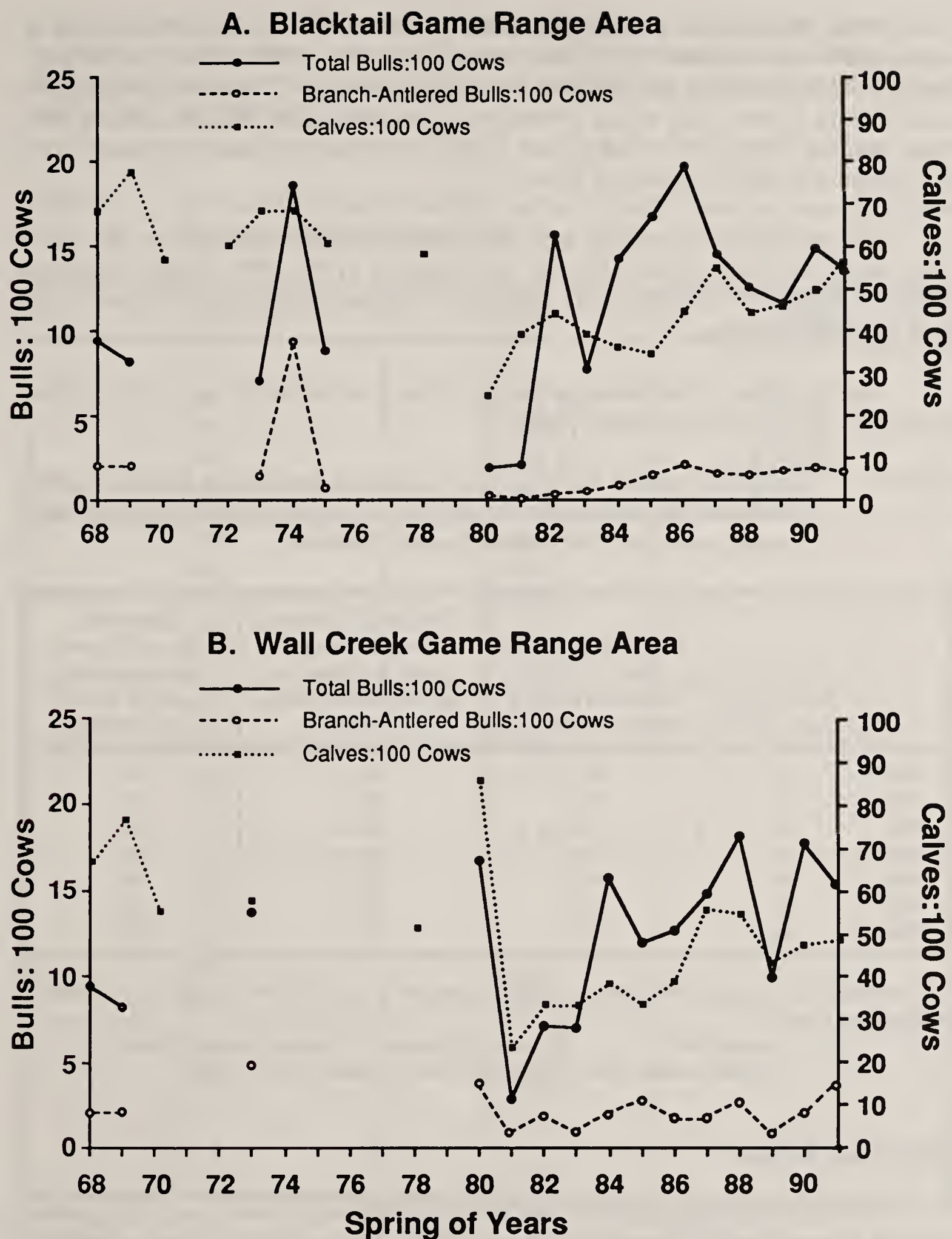


Figure 3. Sex and age structure of elk populations on the (A) Blacktail Game Range and (B) Wall Creek Game Range during spring, 1968-1991.

With the change in hunting regulations to brow-tined bull, the lower harvest in autumn 1990 and the relatively high survival rate of bulls in 1990-91, the observed post-season bull:100 cow ratio should have been a minimum of 18:100 and bulls should have comprised more than 10% of the population. Observed ratios and percentages were lower than that during 1991 (Tables 2 and 3, Fig. 3), primarily reflecting unusually wide distribution and under-counting of bulls.

The percentage of yearling bulls with branched antlers observed on the winter range increased from around 3% after BAB seasons (1985-1990, Hamlin and Ross 1990b) to about 10% in spring 1991 (Table 2). This percentage is still below the 20-25% expected, however.

Age structure of harvested females continued to reconcile well with previous spring calf:100 cow classifications (Table 4).

Table 4. Estimated percent yearling cows in autumn populations based on spring classifications and estimated calf:100 cow ratios the previous spring based on age structure of the female harvest, 1984-90.

	Calves:100 cows Spring classification	Estimated % yearling cows in autumn population based on spring classifications*	Estimated % yearling cows in autumn population based on age structure of hunter harvest	Estimated calves:100 cows previous spring based on harvest age structure
1984	38	16.0	17.7	43
1985	66	24.8	15.1	35
1986	42	17.4	18.8	46
1987	56	22.0	21.4	55
1988	50	19.9	22.8	59
1989	45	18.8	19.1	50
1990	49	19.7	21.7	54

* The projected % yearlings in the autumn population based on spring calf:100 cow ratios is calculated in the following way:

spring 1984: 38 calves:100 cows = 19 female calves:100 cows
summer-autumn 1984: 19 yearling cows/119 total cows = 0.1597

Capture and Harvest

As in previous years, reported sex ratio of calves in the harvest and during winter trapping favored females (Hamlin and Ross 1990b). During 1990-91, harvest ratio (15 males:36 females) and winter trapping ratio (36 males:60 females) were shifted toward females even more than usual. We have not determined whether these samples represent the true sex ratio or are biased in some manner by hunter report or trapping technique.

Age structure of 1990 hunter-killed elk (Table 5, Fig. 4) indicated few males in the population older than 2 years and a sharp decline in females older than 6 years. These results coincide with those of 1989 and indicated that calf production improved starting with the 1984 birth year.

Table 5. Sex and age structure of elk checked at hunter check stations and of jaws left in jaw barrels during 1990.

Age	Females	Males
½	36 ^a	15
1½	53 (21.7) ^b	3 (1.3) ^c
2½	53 (21.7)	68 (85.0)
3½	36 (14.8)	8 (10.0)
4½	23 (9.4)	3 (3.8)
5½	18 (7.4)	
6½	23 (9.4)	
7½	7 (2.9)	
8½	9 (3.7)	
9½	5 (2.0)	
10½	4 (1.6)	
11½	6 (2.4)	
12½	2 (0.8)	
13½	--	
14½	2 (0.8)	
15½	--	
16½	--	
17½	--	
18½	1 (0.4)	
19½	1 (0.4)	
20½	--	
21½	1 (0.4)	
unk. 1+	6	
unk. 2+	--	5
No. 1½+	244 + 6	

^a number

^b number (%) of 1½+ year-olds

^c two of the yearling males were illegal kills; percentages are only reported for legal kills

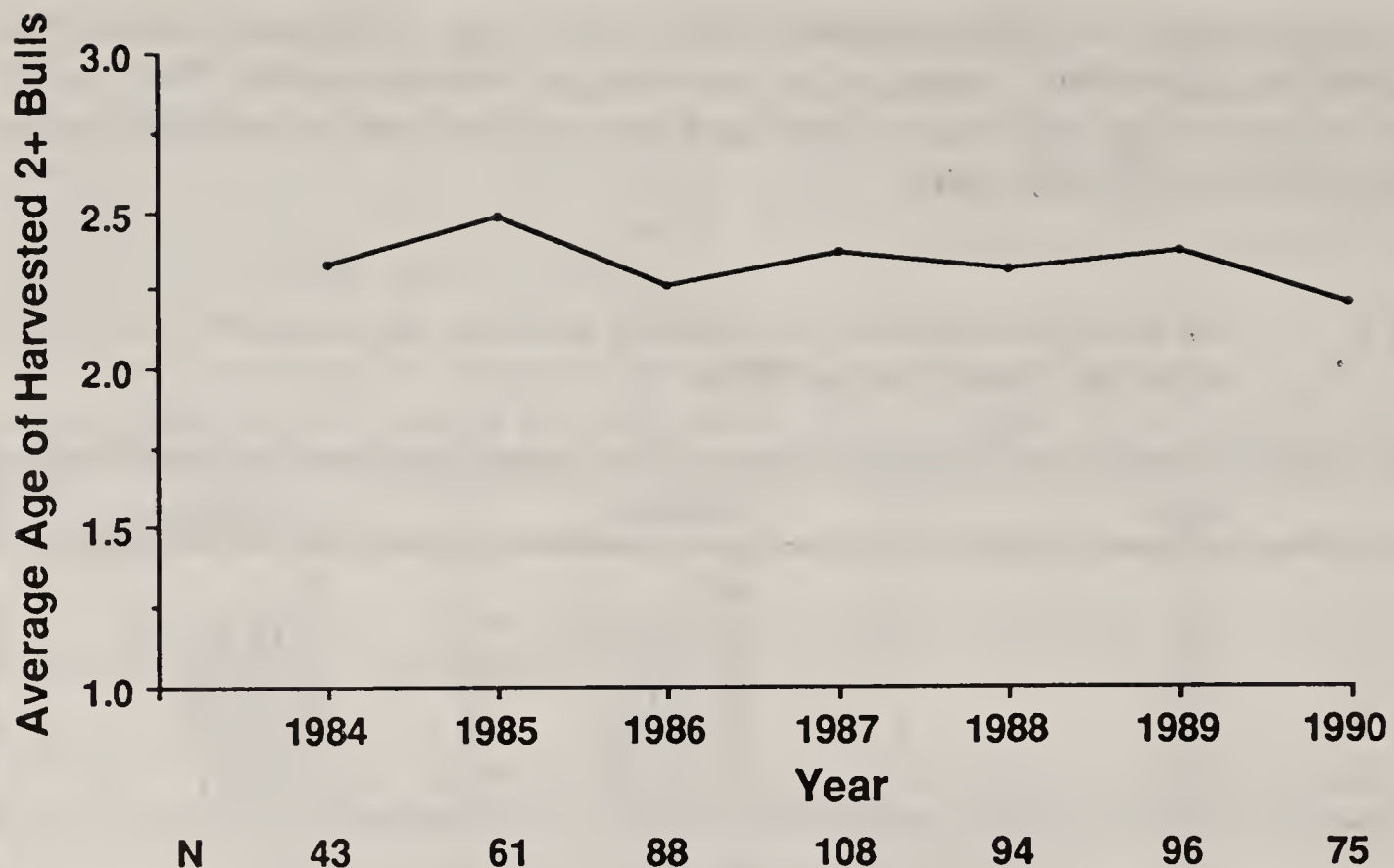


Figure 4. Average age of 2+ year-old bulls harvested in Gravelly-Snowcrest hunting districts, 1984-1990.

Some problem continues with aging at check stations. Two and three-year-old males especially have often been aged one year older than incisors indicate. Antler size may influence aging at check stations.

Condition Parameters

Weight and Diastema

Field dressed weight of hunter-harvested male and female calves were about 23 and 18 pounds (14% and 12%) heavier in 1990 than 1989 (Table 6). Similarly, diastema length was 4.7 mm and 4.1 mm (5.8% and 5.0%) longer for male and female calves in 1990 than 1989 (Table 6). Heart-girth measurements (Smart et al. 1973, Dusek 1990) of calves captured during February (Table 7) also indicated that calves from the 1990 birth year were larger than those of the 1989 birth year. These same data (Table 7) indicated larger calves on the BTGR than on the WCGR.

Blood Chemistry and Hematology

Blood chemistry, hematology, and disease measurements were made for captured elk by the Montana State Diagnostic Lab in Bozeman. We hoped to establish normal values for various blood parameters and also determine if any parameters were useful in

Table 6. Average weight and diastema length for hunter-killed elk calves in the Gravelly-Snowcrest Mountains, 1984-1991.

	Weight (lbs)		Diastema (mm)	
	Male	Female	Male	Female
1984	200.2 (5) ^a	159.1 (9) ^a	83.7 (6) ^b	79.1 (14) ^b
1985	178.0 (4)	178.7 (6)	81.8 (20)	81.7 (34)
1986	179.0 (8)	156.7 (9)	82.2 (16)	80.5 (35)
1987	172.5 (2)	150.7 (7)	82.1 (21)	84.2 (32)
1988	166.8 (9)	152.2 (10)	85.9 (9)	82.3 (21)
1989	160.8 (9)	146.8 (10)	81.1 (24)	81.7 (26)
1990	183.8 (4)	164.8 (10)	85.8 (8)	85.8 (16)

^a weight in lbs (sample size)

^b diastema in mm (sample size)

Table 7. Heart-girth measurement in inches for elk calves captured during February on the WCGR and BTGR.

		1990	1991
Males - WCGR	$\bar{X}$ = n = S_x = Range =	49.5 17 2.1 46.5-54.0	50.5 22 2.1 47.0-54.0
Males - BTGR	$\bar{X}$ = n = S_x = Range =	49.8 23 2.3 44.5-54.0	51.6 14 2.2 48.0-54.5
Females - WCGR	$\bar{X}$ = n = S_x = Range =	48.8 21 2.7 40.0-53.0	49.9 30 2.0 45.0-55.0
Females - BTGR	$\bar{X}$ = n = S_x = Range =	49.7 23 1.9 46.0-53.0	50.6 30 2.2 46.0-53.5

monitoring physical condition of elk. Blood chemistry (Table 8) and hematology (Table 9) values are presented for all elk, newborns, 9-10 month old calves, yearling and older elk captured by drive netting, and yearling and older elk captured by immobilizing drugs.

The data (Tables 8 and 9) indicated that blood parameter values for newborns were usually much different than those of adults or 9-10 month old calves. To establish normals, blood from newborns must be analyzed and interpreted separately from older elk. Similarly, we determined that several blood parameters from elk captured by drive netting were different (Tables 8 and 9) from those captured by use of immobilizing drugs (Carfentanil and Xylazine). Physical restraint often results in contraction of the spleen which releases red blood cells and plasma into the blood (Mark Johnson, DVM, pers. comm.). This results in hemoconcentration, including an increase in red blood cells (RBC), hematocrit (HCT), hemoglobin (HGB, and total protein (TP) (M. Johnson, DVM, pers. comm., Wesson et al. 1979). We also observed that values for all four of these parameters were higher for elk captured by drive netting than those captured by chemical immobilization (Tables 8 and 9).

Chemical immobilization with narcotic drugs generally reduces stress and excitement in animals. Thus, chemical immobilization may result in hemodilution rather than hemoconcentration (Wesson et al. 1979) and has the opposite effect on RBC, HCT, HGB, and TP than noted for physically restrained animals. Natural values for these parameters may be somewhere between those recorded for drugged and physically restrained elk (Tables 8 and 9). Other differences we noted between physically restrained and chemically immobilized elk were higher values for white blood cells (WBC) (especially Segmented and Lymphocyte portions), blood urea nitrogen (BUN), and Potassium and also a lower value for Triglycerides among physically restrained elk (Tables 8 and 9). It is clear that comparisons of values of blood parameters among elk must take method of capture into account.

There may also be differences in values by sex, but we captured too few adult males for comparisons.

It appeared that values for some parameters may vary with age beyond the differences noted for newborns (Fig. 5). Thus, comparisons of values among elk between years and/or locations may have to be partitioned by age class to be valid.

Because of differences in sex and age composition, location, and method of capture, comparison of blood parameter values among years for condition indexes was limited. The most consistently available age classes for comparisons were 9-10 month old calves and 3-year old and older females. We could not detect significant correlations between blood variable values for these age/sex classes and calf weight and diastema length values for 1984-1990. Similarly, no consistent relationships were observed between most blood variable values and calf survival rates. Possible exceptions may occur for Alkaline Phosphatase and HCT, however. A general relationship of rising

Table 8. Blood chemistry for 703 elk captured as newborns through old age in the Gravelly-Snowcrest Mountains during 1984-1991.

			BUN (mg/dl)	Total Protein (g/dl)	Albumin (g/dl)	Alb./Tot. Protein (%)	Calcium (mg/dl)	Magnesium (mg/dl)	Inorganic Phosphorus (mg/dl)	Sodium (mEq/liter)
All Elk	$\bar{X}$ SE CV(%) Range n	19.6 0.2 26.7 8-41 703	6.77 0.03 10.9 3.7-10.4 703	4.58 0.03 15.6 1.7-6.0 703	67.7 0.3 12.8 22.7-92.7 703	10.95 0.04 10.4 5.8-15.9 703	2.36 0.02 14.7 1.3-3.8 462	6.10 0.08 35.6 1.5-18.5 703	142.8 0.7 10.3 68-167 460	
Newborns	$\bar{X}$ SE CV(%) Range n	17.2 0.6 27.7 8-38 68	5.68 0.07 10.5 3.9-7.5 68	2.97 0.07 18.8 1.7-4.2 68	52.9 1.4 21.2 22.7-75.0 68	11.40 0.13 9.4 8.8-15.9 68	2.33 0.05 17.9 1.4-3.3 68	10.28 0.22 17.5 5.9-13.7 68	139.8 0.8 5.0 116-151 68	
9-10 month old calves	$\bar{X}$ SE CV(%) Range n	21.0 0.3 24.6 9-41 289	6.66 0.03 6.6 4.7-8.6 289	4.77 0.02 7.7 3.7-6.0 289	71.8 0.3 6.6 54.4-84.4 289	10.78 0.06 9.7 7.7-14.5 289	2.36 0.02 10.9 1.9-3.3 119	6.11 0.10 28.1 2.8-18.5 289	143.5 1.4 10.5 95-164 119	
1.5+ year old captured by drive netting	$\bar{X}$ SE CV(%) Range n	19.3 0.3 26.0 10-39 304	7.17 0.04 10.2 3.7-10.4 304	4.77 0.03 11.7 2.3-5.9 304	66.9 0.4 11.3 27.9-92.7 304	11.0 0.07 11.6 5.8-15.2 304	2.42 0.02 14.4 1.3-3.8 233	5.33 0.09 29.7 1.5-11.8 304	143.7 1.1 12.0 68-167 231	
1.5+ year old 1989 captured by immobilizing drugs	$\bar{X}$ SE CV(%) Range n	15.5 0.6 25.8 9-27 42	6.42 0.06 6.4 5.5-7.5 42	4.40 0.04 6.4 3.9-5.0 42	68.7 0.6 6.1 58.7-79.3 42	10.98 0.08 4.7 10.2-12.2 42	2.05 0.04 12.4 1.4-2.5 42	4.79 0.17 22.6 2.7-6.8 42	141.2 0.6 2.6 131-150 42	

Table 8. Continued

		Potassium (mEq/dl)	Alkaline Phosphatase (IU/l)	Triglycerides (mg/dl)	CPK	SGOT (IU/l)	GGT (IU/l)	Creatinine (mg/dl)	Total Bilirubin (mg/l)	Globulin (g/dl)
All elk	$\bar{X}$ SE CV(%) Range n	15.6 0.4 58.9 2.4-45.0 460	205.0 8.7 113.0 19-2190 701	50.9 1.3 52.0 8-207 442	1038.5 43.9 65.6 121-3377 241	99.3 2.1 33.3 35-211 247	36.2 1.5 65.9 4-294 241	3.58 0.03 11.7 2.6-4.7 239	0.87 0.04 67.4 0.0-3.1 241	2.07 0.05 25.0 1.1-4.8 129
Newborns	$\bar{X}$ SE CV(%) Range n	8.5 0.3 32.6 2.4-16.6 68	789.6 40.7 42.5 275-2190 68	68.6 5.7 57.5 17-172 48	-	43.2 4.1 23.4 35-58 6	-	-	-	-
9-10 month old calves	$\bar{X}$ SE CV(%) Range n	16.0 0.8 55.2 5.8-38.9 119	143.5 3.5 41.4 19-454 287	49.1 1.8 40.5 18-124 119	1163.6 54.1 60.6 209-3377 170	103.8 2.6 32.1 46-211 170	36.7 2.1 73.7 5-294 170	3.55 0.03 12.0 2.6-4.7 168	0.96 0.05 61.8 0.0-3.1 170	1.90 0.05 23.3 1.1-4.8 86
1.5+ year old captured by drive netting	$\bar{X}$ SE CV(%) Range n	18.1 0.7 55.5 5.6-45.0 231	136.6 5.1 64.8 20-557 304	45.8 1.3 41.9 8-141 233	739.1 60.7 69.2 121-2500 71	93.4 3.4 30.3 49-196 71	35.0 1.6 39.1 4-68 71	3.66 0.05 10.9 2.9-4.6 71	0.67 0.06 79.1 0.0-2.0 71	2.44 0.08 20.0 1.7-4.5 42
1.5+ year old 1989 captured by immobilizing drugs	$\bar{X}$ SE CV(%) Range n	12.1 0.4 23.6 8.2-19.5 42	173.7 21.8 81.3 44-847 42	64.0 6.6 66.9 13-207 42	-	-	-	-	-	-

Table 9. Hematology for 682 elk captured as newborns through old age in the Gravelly-Snowcrest Mountains during 1984-1991.

		RBC (10 ⁶ /MI)	MCV (fl)	HCT (Vol. %)	HGB (g/dl)	WBC (10 ³ /MI)
All Elk	$\bar{X}$ SE CV(%) Range n	9.8 0.7 17.3 4.9-13.8 614	51.4 0.2 8.8 39-83 614	51.4 0.3 16.2 22.9-72.0 682	18.1 0.1 16.5 7.5-26.0 614	4.90 0.06 32.2 1.1-11.9 614
Newborns	$\bar{X}$ SE CV(%) Range n	6.5 0.1 14.8 4.9-10.3 69	49.3 0.6 9.4 39-59 69	32.1 0.7 16.9 22.9-49.7 69	10.8 0.3 20.9 7.5-17.9 69	5.41 0.17 25.6 2.0-8.2 69
9-10 month old calves	$\bar{X}$ SE CV(%) Range n	10.6 0.9 13.1 7.7-13.6 262	49.2 0.2 6.2 41-61 262	54.1 0.3 9.5 30-67.1 278	19.0 0.1 5.4 15.6-22.1 262	4.63 0.09 31.2 1.7-8.8 262
1.5+ year old captured by drive netting	$\bar{X}$ SE CV(%) Range n	10.1 0.7 10.0 7.6-13.8 241	53.7 0.3 8.1 45-83 241	53.8 0.3 9.5 39-72 293	19.3 0.1 6.4 16.5-26.0 241	5.34 0.10 29.7 1.9-11.9 241
1.5+ year old 1989 captured by immobilizing drugs	$\bar{X}$ SE CV(%) Range n	8.9 0.1 8.9 6.8-10.5 42	55.9 0.5 5.6 48-64 42	49.2 0.6 8.3 40.4-58.6 42	16.8 0.2 6.3 14.4-18.5 42	3.28 0.18 35.0 1.1-5.8 42

Table 9. Continued

		Band (10 ³ /MI)	Segmented (10 ³ /MI)	Lymphocytes (10 ³ /MI)	Monocytes (10 ³ /MI)	Eosinophils (10 ³ /MI)	Basophils (10 ³ /MI)	Neutrophil: Lymphocyte Ratio	NRBC No./100 WBC
All Elk	$\bar{X}$ SE CV(%) Range n	0.06 0.01 218.5 0.0-1.04 614	2.28 0.05 57.0 0.18-8.69 614	2.21 0.03 33.7 0.0-5.83 614	0.03 0.002 175.0 0.0-0.37 614	0.31 0.01 97.0 0.0-21.7 614	0.03 0.002 172.7 0.0-0.31 614	1.17 0.03 71.2 0.14-7.37 613	-
Newborns	$\bar{X}$ SE CV(%) Range n	0.11 0.02 147.4 0.0-0.80 69	3.10 0.16 42.2 0.5-6.89 69	2.01 0.08 32.9 0.0-3.58 69	0.05 0.01 129.1 0.0-0.30 69	0.08 0.01 136.4 0.0-0.58 69	0.04 0.01 147.6 0.0-0.31 69	1.79 0.15 69.5 0.41-7.37 68	8.2 1.3 122.1 0-60 58
9-10 month old calves	$\bar{X}$ SE CV(%) Range n	0.04 0.005 202.1 0-0.70 262	2.08 0.07 53.5 0.32-5.63 262	2.17 0.04 32.4 0.48-5.20 262	0.03 0.003 183.8 0-0.37 262	0.30 0.02 110.8 0-2.17 262	0.03 0.003 170.1 0-0.31 262	1.07 0.04 62.4 0.2-3.5 262	-
1.5 year old captured by drive netting	$\bar{X}$ SE CV(%) Range n	0.08 0.01 220.1 0-1.04 241	2.50 0.09 53.9 0.39-8.69 241	2.36 0.05 33.2 0.9-5.83 241	0.03 0.003 183.7 0-0.22 241	0.36 0.02 75.5 0-2.12 241	0.02 0.003 193.4 0-0.29 241	1.21 0.05 65.6 0.14-4.34 241	-
1.5 + year old 1989 captured by immobilizing drugs	$\bar{X}$ SE CV(%) Range n	0.004 0.002 382.2 0.0-0.08 42	0.90 0.08 56.3 0.18-2.59 42	1.89 0.11 36.9 0.75-3.89 42	0.03 0.007 173.3 0.0-0.18 42	0.41 0.04 58.4 0.0-0.93 42	0.05 0.01 134.8 0.0-0.24 42	0.50 0.04 54.2 0.14-1.42 42	-

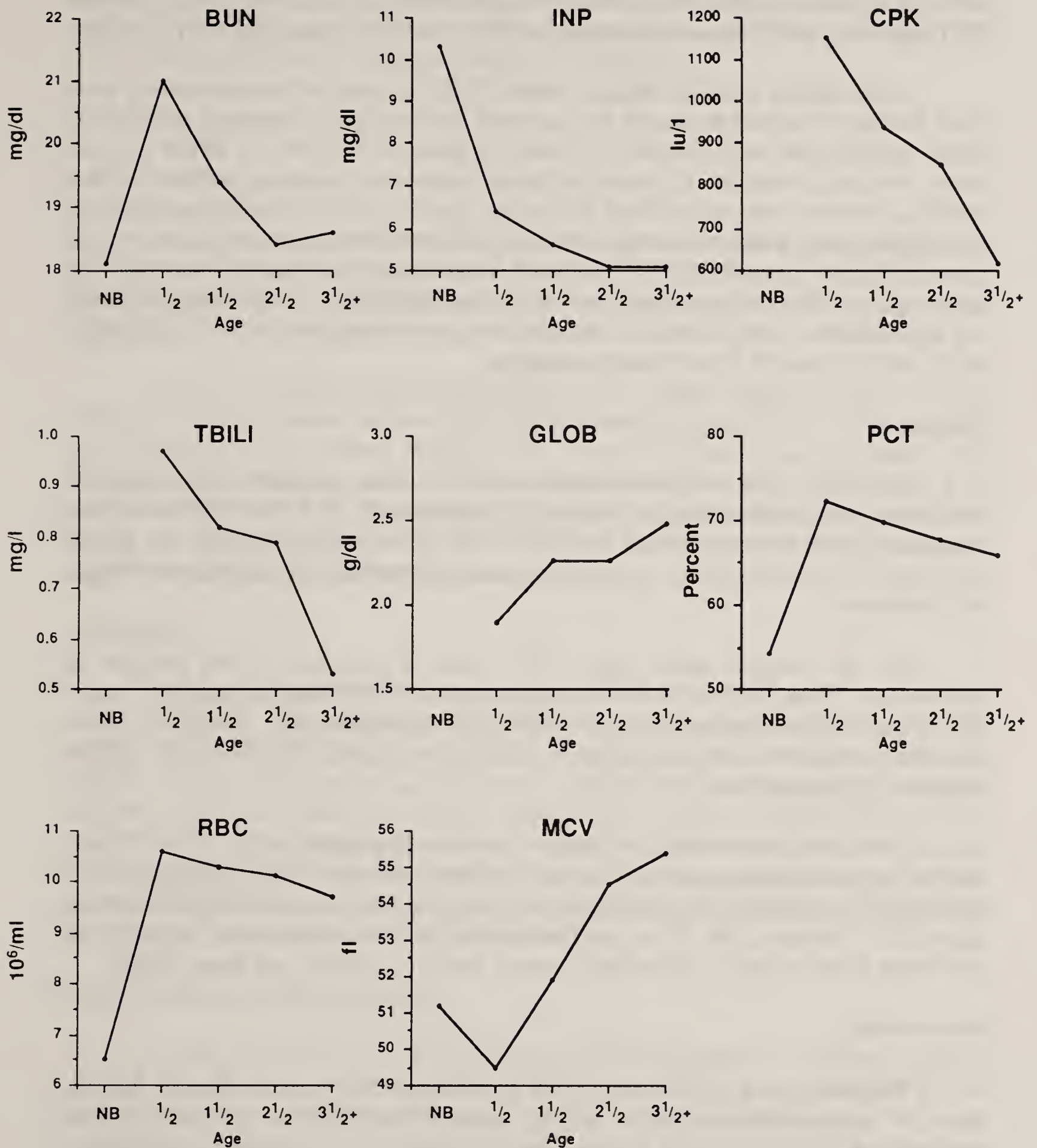


Figure 5. Observed variation in values of various blood parameters by age for female elk. Newborn values are for both sexes.

values with increasing calf survival may exist for Alkaline Phosphatase level and spring calf:100 cow ratios (male calf-Alk Phos, $r=0.89$; female calf-Alk Phos, $r=0.61$) and for HCT and spring calf:100 cow ratio (male calf-HCT, $r=0.82$, female calf-HCT, $r=0.90$).

Small sample sizes for sex/age classes of elk in variable locations during some years probably hindered the search for statistical relationships. Consistent collection of blood samples from large numbers of calves on both the WCGR and BTGR in future years may help determine the value of blood samples as condition indicators. It is possible, however, that many blood parameters may have little value for assessing elk herd health. Until health is severely affected, homeostasis results in only a narrow range of variability for many values. Animals with severe health problems are also less likely to be captured. Detecting problems with even those animals by use of blood parameters can be difficult. Two males with at least low-grade infections showed no apparent deviation from normal in any blood parameters.

Disease

All 132 blood samples collected in 1991 were negative for brucellosis, bluetongue, and anaplasmosis. A total of 11 individual elk (8.6%) of 128 tested were positive reactors for leptospirosis in 1991. Five were positive reactors for serovar autumnalis, four were positive for grippotyphosa, and one each for icterohaemorrhagiae and tarassovia.

For all samples tested since 1984, none of 674 have tested positive for bluetongue. Three (0.45%) of 673 elk tested positive for brucellosis and there were 6 (0.9%) positive and 3 suspect reactors of 671 elk for anaplasmosis. Excluding serovar bratislava, which was only tested for in 1990, 114 (17.1%) of 668 elk had positive reactions for leptospirosis.

There has been nothing to indicate that the elk population has suffered major mortality or reproductive problems as a result of these diseases. The positive results can just mean that elk have been exposed to the disease and have developed antibodies against it. However, the three positive reactors for brucellosis were collected and confirmed to be infected with *Brucella abortis* biovar 1 (Hamlin and Ross 1990a).

Reproduction

Pregnancy rates for February 1991 as determined by level of Protein B in the blood of captured elk was similar to prior years. Two (20%) of 10 yearlings were pregnant and 27 (96.4%) of 28 females 2-years and older were pregnant. Additionally, one yearling and two older females were tested only by the ultrasound pregmatic machine. The yearling was called open, and the two older females pregnant.

For all years, 1984-1991, 23 (33.3%) of 69 yearlings were determined to be pregnant, 34 (97.1%) of 35 2-year-olds, 133 (96.4%) of 138 3-5-year-olds, 49 (94.2%) of 52 6-8-year-olds, and 9 (90%) of 10 9+-year-olds were pregnant. A total of 232 (95.9%) of 242 females 2 years and older were pregnant.

Mortality

Adult Females

Annual mortality rate for a sample of adult females with functioning radio-transmitter collars was 15.5%, similar to that of 1987-89 (Table 10). Annual mortality attributable to hunting was 12.7%. Over a seven year period, 89% of the annual mortality of adult cows was hunting related. Crippling loss has been 11.4% of legal kill.

Causes of mortality were very similar from a larger sample that also included cows with only neckbands and non-functioning transmitters (Table 11). Eleven (8.8%) of 125 known hunting related mortalities of marked adult cows were in Idaho. Six (3.2%) of 189 known legal hunting related mortalities of all adult marked elk were archery related (Table 11). Data from the statewide questionnaire indicated that archery harvest accounted for 2.3% and 3.8% of total elk harvest in the Gravelly-Snowcrest complex in 1989 and 1990, respectively.

Adult Males

Ninety-nine percent of known causes of death for marked males was hunting related (Table 11). Of 38 yearling males with functioning radio-transmitter collars that entered the 1990 BTB hunting season, 31 (81.6%) survived. Four (10.5%) were probable illegal mortalities, one (2.6%) was a possible illegal mortality or slipped collar, and two (5.3%) were legally harvested in Idaho. Only one (14%) of seven 2+ year-old bulls with functioning transmitter collars was harvested. Harvest rate of 2+ year-old bulls was undoubtably higher than indicated by the small radio-collared sample, but did appear to be lower than in previous years. Seven (9.9%) of 71 known hunting related mortalities of marked adult bulls were in Idaho.

Harvest Surveys and Check Stations

As was expected during the first year of BTB regulations, total bull harvest declined (Fig. 6) owing to the reduction in harvest of yearling bulls. Number of 2+ year-old bulls harvested remained stable as did the number of hunters.

Check station data (Table 12) indicated a 10% decline in hunter numbers, a 23% decline in antlerless harvest, and a 33% decline in bull harvest. Statewide questionnaire data indicated less than 1% decline in hunter numbers, a 16% decline in antlerless harvest, and a 21% decline in bull harvest. Most of the decline in hunter numbers at

Table 10. Mortality rates of adult female elk (≥ 1 year) based on a sample with functioning radio-transmitter collars.

Time	N	Total Deaths	Shot	Crippling Loss	Shot - Not Reported	Natural ^a	Unknown	Total Hunting Related
1 June 1984 - 31 May 1985	26	2 (7.7) ^b	1	0	0	1	0	1 (3.9) ^b
1 June 1985 - 31 May 1986	52	4 (7.7)	2	1	1	0	0	4 (7.7)
1 June 1986 - 31 May 1987	59	3 (5.1)	2	0	0	1	0	2 (3.4)
1 June 1987 - 31 May 1988	64	11 (17.2)	11	0	0	0	0	11 (17.2)
1 June 1988 - 31 May 1989	64	11 (17.2)	10 ^c	0	1	0	0	11 (17.2)
1 June 1989 - 31 May 1990	79	13 (16.5)	9	1	1	1	1	11 (13.9)
1 June 1990 - 31 May 1991	71	11 (15.5)	5	3	1	1	1	9 (12.7)
Total		55	40 (72.7)	5 (9.1)	4 (7.3)	4 (7.3)	2 (3.6)	49 (89.1)

^a Natural loss includes old age, malnutrition, disease, calving problems, predation, etc.

^b Number (%)

^c Includes one archery-kill

Table 11. Causes of mortality for radio-transmitter collared and neckbanded adult elk (≥ 1 year), 1984-1991.

Causes of Mortality	Females	Males	
		1-2 Years	≥ 2 Years
Rifle hunting	106 (79.1) ^a	9 (52.9)	51 (92.7)
Archery hunting	3 (2.2)	-	1 (1.8)
Crippling loss - abandonment (rifle) ^b	10 (7.5)	-	2 (3.6)
Crippling loss - abandonment (archery) ^b	1 (0.8)	-	1 (1.8)
Shot and not reported or returned ^b	5 (3.7)	-	-
Illegal kill ^{bc}	-	7 (41.2)	-
Natural deaths ^b	6 (4.5)	1 (5.9)	-
Unknown	3 (2.2)	-	-
TOTAL	134	17	55
Total Hunting Related	125 (93.3)	16 (94.1)	55 (100)

^a Number (%)

^b Because animals with non-functioning radio-transmitter collars and neckbands are included, the number and % in these categories is an absolute minimum.

^c Because of some problems with collar loss in 1990, illegal kill of yearling bulls may be somewhat overestimated for that year.

check stations occurred at Dillon. This may have occurred because several any antlered bull (AB) areas are located near Dillon, thereby giving Dillon area hunters more hunting alternatives.

Abandoned elk, crippling loss, and/or illegal kill reported at check stations remained similar to previous years for antlerless elk, but was 28 for bulls in 1990 compared to 41 in 1989 and 82 in 1988.

Emigration and Immigration

To determine the degree of emigration occurring in Gravelly-Snowcrest elk herds, we summarized all cases where radio-collared elk were known to switch winter ranges. Not all of these cases were permanent movements, some went back to the original winter range in a subsequent year. In those cases, a second emigration was recorded at the later age. The following figures do not include movements between two adjacent winter ranges in the same winter or weather-related shifts in wintering area; those cases are discussed separately.

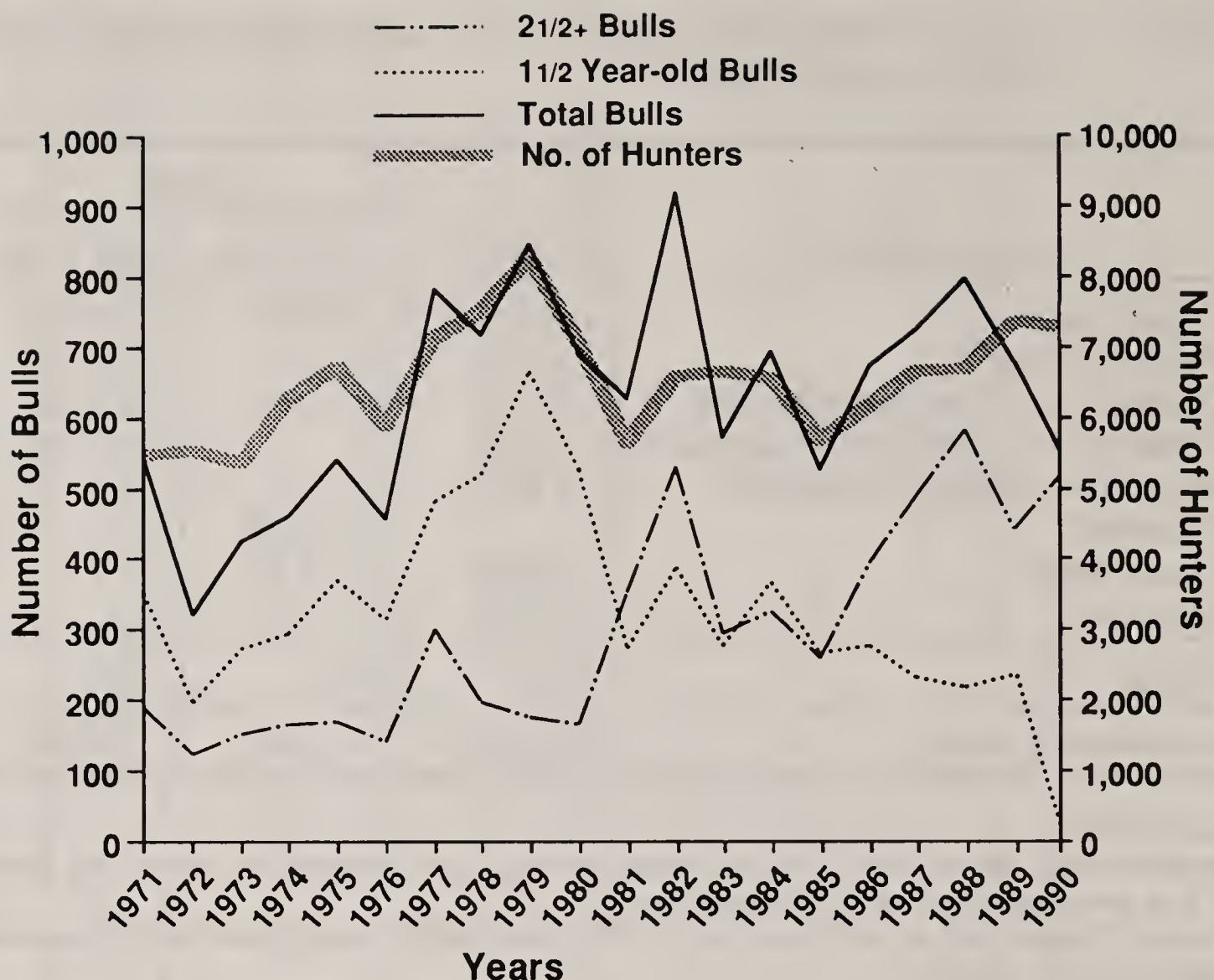


Figure 6. Number of hunters and harvest of total bulls, yearling bulls, and 2+ year-old bulls in Gravelly-Snowcrest hunting districts as estimated by the statewide hunter questionnaire, 1971-1990.

Seven (28.0%) of 25 females were known to spend their yearling winter on a different winter range than they used as a calf. Ten (22.7%) of 44 females spent their 2-year-old winter on a different winter range than they used as a yearling. Six (15.0%) of 40 females used a different winter range as a 3-year-old than they used as a 2-year-old. Females 3 years and older used a different winter range one year than they had used in previous years during 14 (6.8%) of 206 elk-years. These data indicated relatively high emigration rates at young ages, declining with maturity. Overall, females switched winter ranges in 37 (11.8%) of 315 elk-years.

For males, 3 (8.3%) of 36 wintered on a different winter range as yearlings than they had used as calves. Five (38.5%) of 13 used a different winter range as 2-year-olds than they used as yearlings. It appears possible that a different emigration pattern will emerge for males than females. Recent increased marking of males will give us more information in future years.

Table 12. Season-long results from hunter check stations operated in the Gravelly-Snowcrest Mountains during 1984-1990.

Check Station ^a	Year	No. Hunters	Elk				Mule Deer			White-tailed Deer		
			Males		Females	Calves	Males	Females	Fawns	Males	Females	Fawns
			Yrlng.	2+								
All	1984	3,425	16	40	97	25	154	106	51	26	6	3
	1985	3,124	12	72	110	31	214	121	29	23	5	3
	1986	6,231	33	89	99	30	309	155	46	63	19	22
	1987	5,075	31	93	135	33	376	135	32	49	14	15
	1988	4,944	36	95	178	39	450	112	28	46	19	18
	1989	5,001	26	97	136	58	328	98	20	50	8	13
	1990	4,508	2 ^b	81	119	30	312	138	34	31	7	3
Ruby	1984	1,698	11	23	57	11	127	100	43	20	6	3
	1985	1,623	10	46	82	27	161	105	27	19	5	3
	1986	2,172	11	42	47	14	146	93	30	33	9	18
	1987	2,135	14	36	69	18	175	83	18	26	4	7
	1988	2,096	14	39	62	19	204	62	15	17	6	9
	1989	1,832	4	28	55	27	147	43	9	19	1	3
	1990	1,830	--	34	43	15	167	56	17	17	5	1
Blacktail Road	1986	1,882	11	20	28	9	102	39	5	24	10	4
	1987	1,930	11	29	38	7	135	38	10	18	10	7
	1988	1,831	11	25	53	3	136	38	9	21	11	7
	1989	2,256	14	40	48	23	137	42	11	26	4	9
	1990	1,781	1 ^b	22	34	9	99	66	11	13	2	1
Ennis	1986	2,177	11	27	24	7	61	23	11	6	0	0
	1987	1,010	6	28	28	8	66	14	4	5	0	1
	1988	1,017	11	31	63	17	110	12	4	8	2	2
	1989	913	8	29	33	8	53	13	0	5	3	1
	1990	897	1 ^b	27	42	6	46	16	6	1	0	1

^a The Upper Ruby Creek Check Station was the only one operated each year 1984-1989. In 1984 and 1985, 2-3 other stations were manned on the east side of the Gravellys. In 1986, those were combined into one station at Ennis and a new station was opened on the Blacktail Road south of Dillon.

^b Illegal kill.

Further investigations will be made on the process of emigration. Tentative indications are that it begins on summer range. There are several areas of summer range that are occupied by elk using a variety of winter ranges. Mixing of elk on summer range may lead to individual elk switching winter range. Another behavior that leads to changes in winter range, especially among bulls, is changes of summer range. Thus far, 8 (40%) of 20 bulls followed have used a different summer range as 2-year-olds than that they used as yearlings. Increased samples at this and older ages will clarify questions about bull movements and home ranges.

A certain portion of elk from closely adjacent winter ranges (e.g. Wall Creek and Cherry-Morgan, and Blacktail and Robb-Ledford) move between winter ranges within the same year. This appears to be at least partially related to summer range area used and migration route to winter range. Other elk may not always return to the same winter range every year if weather conditions are variable. This may be especially true of older bulls. In mild winters, some elk normally wintering on the Wall Creek Game Management area may spend winter in the West Fork of the Madison or near Granite Mountain. Similarly, some elk normally wintering at the Blacktail Game Range and the Robb-Ledford Game Management area winter in the Upper Ruby in mild winters.

Table 13 lists winter range of capture and winter range moved to by radio-collared female emigrators. Neckbanded elk known to switch winter ranges are listed in parenthesis. Changes of winter range were most commonly to a nearby winter range.

Additionally, at least two other females wintered at the Sand Creek winter range in Idaho. We have not definitely identified the individuals involved, so we don't know the winter range of capture. Also, a male calf marked in 1974 on the BTGR was shot in 1975 in Cabin Creek in the Madison Range (HD 360) and a male calf marked on the BTGR on 12-29-75 was shot in 1977 southwest of Jackson, Wyoming. Thus far, we know of a minimum of seven females and five males that emigrated to non-Gravelly populations.

Immigration is often harder to detect within most study areas because it depends upon significant numbers of marked animals in surrounding areas. We have been able in this area to document that immigration has occurred. Brown (1985) reported that 2 (3.8%) of 53 adult cows marked in the Sand Creek population in Idaho had emigrated to the Wall Creek Game Range. One of these cows was still at Wall Creek in 1990 and 1991. Also, one yearling bull marked on Idaho's Sand Creek winter range on November 13, 1964, was shot on October 23, 1966, in the upper West Fork of the Ruby River near Hogback Mountain. Four (7.1%) of 56 bull elk marked on the Flying D Ranch at the north end of the Madison-Gallatin range in 1986 and 1987 emigrated to Gravelly-Snowcrest populations. In October 1968, a 2-year old bull elk that had been marked on the National Elk Refuge near Jackson, Wyoming, was shot in Standard Creek within the Gravellys.

Table 13. Known changes of winter range by radio-collared female elk.

Winter Range of Capture	Winter Range Moved To
Wall Creek WMA	Warm Springs Creek - 3 (2) ^a Sheep Creek - 3 (1) Cherry-Morgan - 2 (3 males) North Centennial Valley - 2 (1) Idaho - 2 (1 female and 1 male) Blacktail WMA - 1 (3) Sun Ranch - 1 (1) Robb-Ledford - 1 Basin-Sage Creek - 1 Tobacco Roots - 1 male
Cherry-Morgan	Wall Creek WMA - 3 Blacktail WMA - 1 Greenhorns - 1
Blacktail WMA	Robb-Ledford - 6 (1) Wall Creek WMA - 2 South Centennials - 1
Robb-Ledford	Blacktail WMA - 2

^a Neckbanded elk switching winter ranges are listed in parenthesis

These scattered data and reports do indicate that both emigration and immigration occur. The degree of balance in movements cannot be determined at this time. These movements must be considered, however, when evaluating the effects of management strategies within any one area.

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